

Machining diamond with sub-ns pulses

Summary : Diamond materials can be cut and machined with PicoSpark laser with excellent quality and accuracy.

The angles are sharp and well-defined and there is no measurable roughness increase for the process parts. There is no heat-affected-zone at all either

The ablation efficiency is not optimized but still reasonable for such hard materials (close to 0.025mm³ per minute for PCD).

Test conditions

Objectives

1. Machining 400µm deep square cavity out of polycrystalline diamond (PCD) sample.
2. Cut the angle of 500µm thick polycrystalline diamond (PCD) and chemical vapor deposition diamond (CVD) at a defined value

Targeted features

- Smooth and well defined cavity walls
- High removal rate
- No burning of the material
- Determination of the ablation rate
- Determination of discrepancy to ideal shape

Experimental setup

PicoSpark amplified microchip laser:

- wavelength 532 nm
- 610 ps pulse duration
- repetition rate from 20 to 40 kHz
- pulse energy up to 100µJ

Scanner head, up to 400 mm/s speed

F-Theta lens with focal length= 100 mm

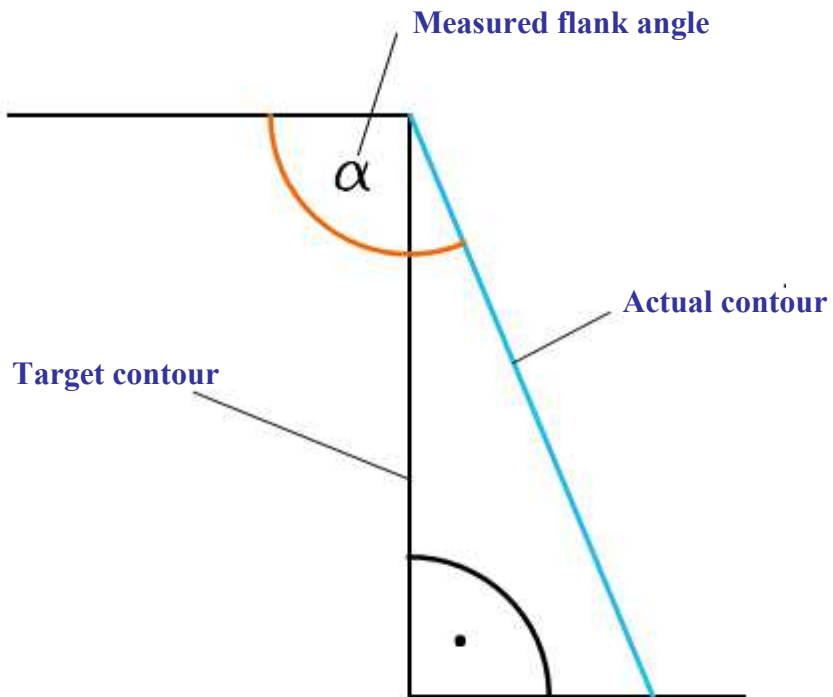
Three linear stages for positioning



Figure 1 : PicoSpark laser

Definitions

The measured flank angle α is defined as follows:



PCD ablation

Target

Abated volume geometry = 2mm x 2mm x 0.4mm = 1.6mm³ (see fig.1)

Minimum roughness increase

Laser parameters

- repetition rate 40 kHz
- wavelength 532 nm
- pulse energy 40 μJ

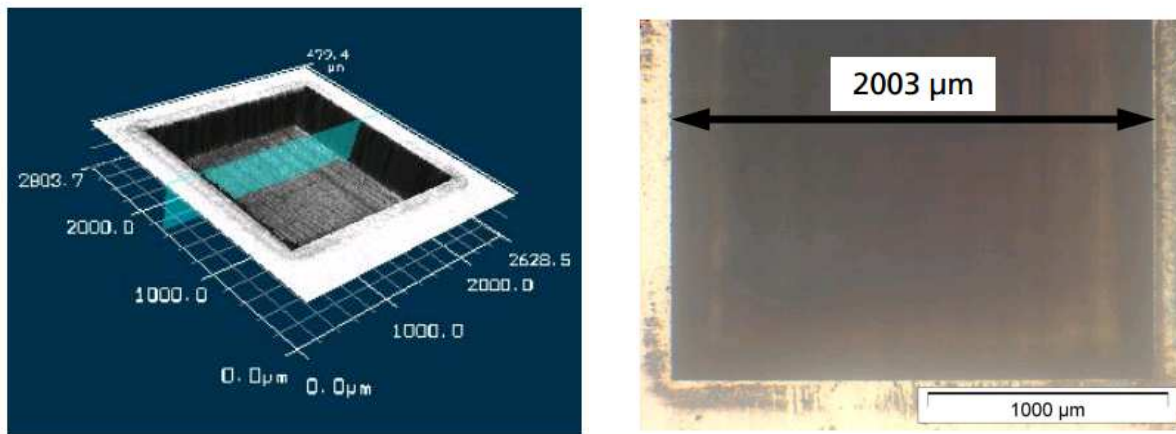


Figure 1 : 3D profile (left) and microscope view (right) of the processed volume in the PCD sample.

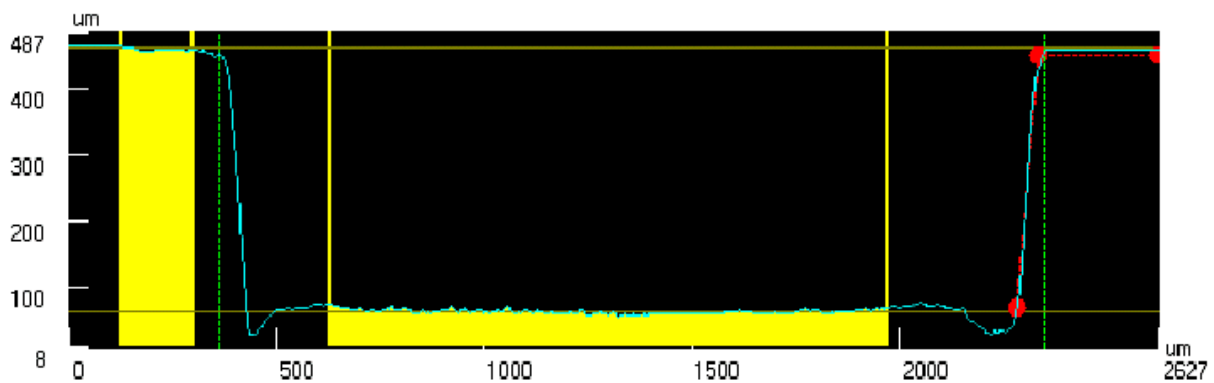


Figure 2 : 2D cut profile of the ablated volume, showing flat bottom, sharp edges and steep side walls.

Results

- Hole-geometry 1980 x 2000 x 399 μm
- Roughness of bottom-surface: Ra ≈ 6 μm = natural PCD roughness
- Flank angle: 98 - 104° for a 90° target (see fig.2)
- Duration: 45 minutes
- Surface cleaned manual with ethanol

PCD cutting

Targets

- Cut angle = 15° (corresponding to 65° flank angle, see fig.3)
- Edge distance = $500\mu\text{m}$

Laser parameters

- repetition rate 40 kHz
- wavelength 532 nm
- pulse energy 40 μJ

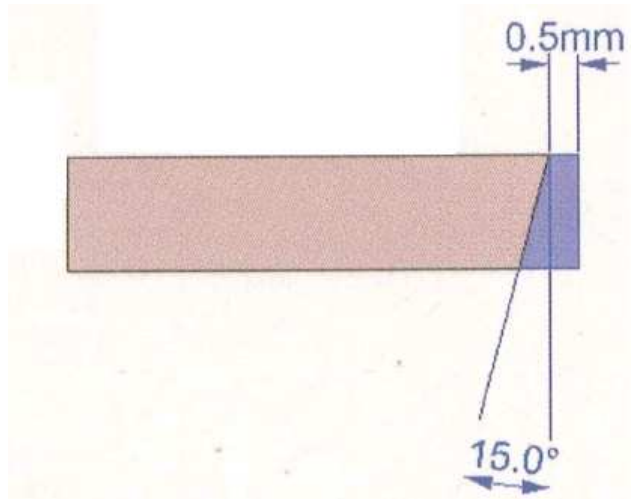


Figure 3 : targeted geometry after cutting

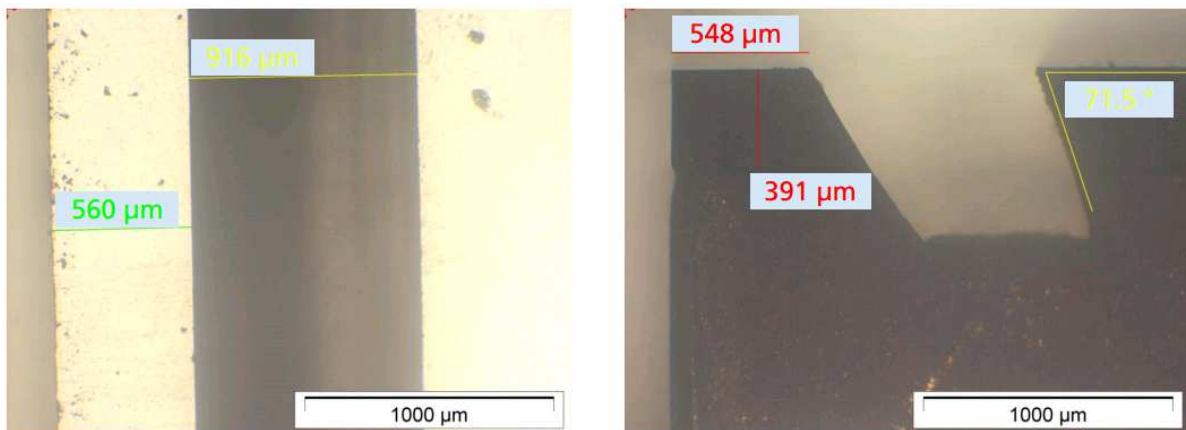


Figure 4 : top-view (left) and side view (right) of the processed PCD sample

Results

- angle $\approx 18,5^\circ$ (flank angle $\approx 71,5^\circ$)
- Edge distance $560\mu\text{m}$
- Processing-time 95 minutes
- Reduce of processing-time is possible by further optimizing cut depth and width

CVD cutting

Target

Cut angle = 15° (corresponding to 65° flank angle, see fig.5)

Laser parameters

- repetition rate 40 kHz
- wavelength 532 nm
- pulse energy 40 μ J

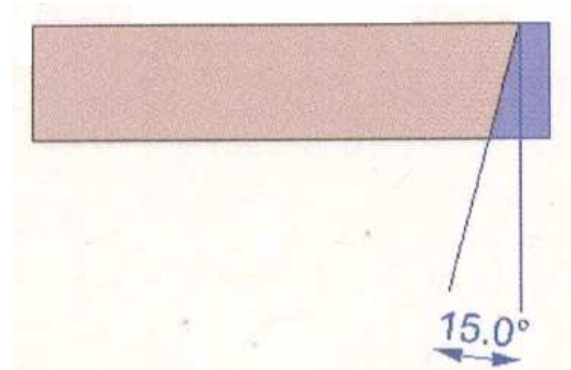


Figure 5: targeted geometry after cutting

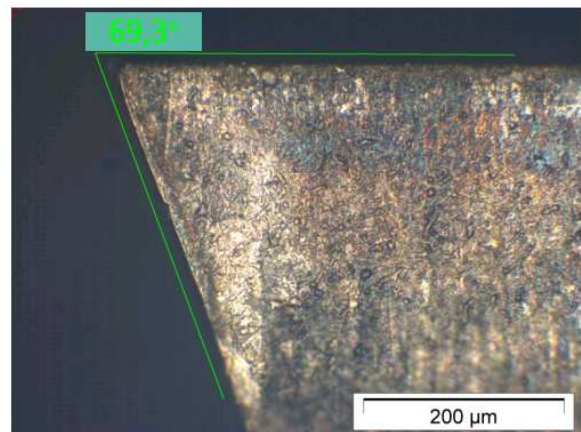
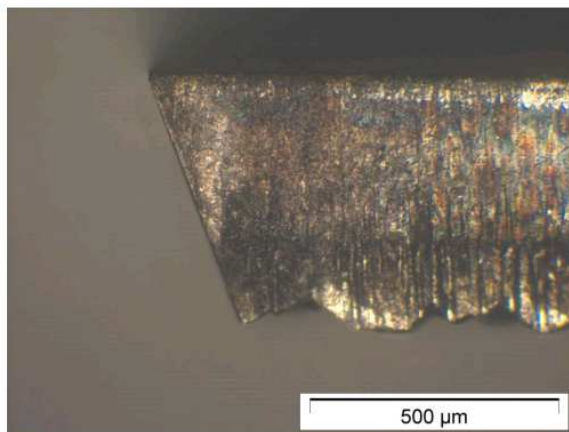


Figure 6: top-view (left) and side view (right) of the processed PCD sample

Results

- angle $\approx 20,7^\circ$ (flank angle $a \approx 69,3^\circ$)
- Processing-time = 95 minutes
- Reduce of processing-time is possible by further optimizing cut depth and width